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## **Gender differences in wheelchair marathon performance &ndash; Oita International Wheelchair Marathon from 1983 to 2011**

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**Abstract:** Background: The purpose of the study was (1) to examine the changes in participation and performance of males and females at the Oita International Wheelchair Marathon in Oita, Japan, between 1983 and 2011, and (2) to analyze the gender difference in the age of peak wheelchair marathon performance. Methods: Age and time performance data for all wheelchair athletes completing the Oita International Wheelchair Marathon from 1983 to 2011 were analyzed. Results: Mean annual number of finishers was  $123 \pm 43$  for males and  $6 \pm 3$  for females ( $5.0\% \pm 2.0\%$  of all finishers), respectively. Mean age of overall finishers was significantly ( $P = 0.026$ ) greater for males ( $41.3 \pm 1.8$  years) compared to females ( $32.7 \pm 1.4$  years). In contrast, there was no difference in the mean age of the top three overall finishers between males ( $35.8 \pm 3.2$  years) and females ( $31.6 \pm 1.5$  years). The race time of the top three overall finishers was significantly lower ( $P < 0.01$ ) for males ( $1:34 \pm 0:11$  hours:minutes) compared to females ( $1:59 \pm 0:20$  hours:minutes), but it was not significantly different between male ( $2:06 \pm 0:12$  hours:minutes) and female ( $2:12 \pm 0:18$  hours:minutes) overall finishers. The mean gender difference in time was  $26.1\% \pm 9.7\%$  for the top three overall finishers. Conclusion: Further studies are required to investigate the reasons for the low participation of females in wheelchair marathons and why the gender difference in marathon performance is much greater for disabled athletes than for able-bodied athletes.

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# Gender differences in wheelchair marathon performance – Oita International Wheelchair Marathon from 1983 to 2011

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**Background:** The purpose of the study was (1) to examine the changes in participation and performance of males and females at the Oita International Wheelchair Marathon in Oita, Japan, between 1983 and 2011, and (2) to analyze the gender difference in the age of peak wheelchair marathon performance.

**Methods:** Age and time performance data for all wheelchair athletes completing the Oita International Wheelchair Marathon from 1983 to 2011 were analyzed.

**Results:** Mean annual number of finishers was  $123 \pm 43$  for males and  $6 \pm 3$  for females ( $5.0\% \pm 2.0\%$  of all finishers), respectively. Mean age of overall finishers was significantly ( $P = 0.026$ ) greater for males ( $41.3 \pm 1.8$  years) compared to females ( $32.7 \pm 1.4$  years). In contrast, there was no difference in the mean age of the top three overall finishers between males ( $35.8 \pm 3.2$  years) and females ( $31.6 \pm 1.5$  years). The race time of the top three overall finishers was significantly lower ( $P < 0.01$ ) for males ( $1:34 \pm 0:11$  hours:minutes) compared to females ( $1:59 \pm 0:20$  hours:minutes), but it was not significantly different between male ( $2:06 \pm 0:12$  hours:minutes) and female ( $2:12 \pm 0:18$  hours:minutes) overall finishers. The mean gender difference in time was  $26.1\% \pm 9.7\%$  for the top three overall finishers.

**Conclusion:** Further studies are required to investigate the reasons for the low participation of females in wheelchair marathons and why the gender difference in marathon performance is much greater for disabled athletes than for able-bodied athletes.

**Keywords:** endurance, sex difference, disabled athlete, spinal cord injury

## Introduction

Wheelchair racing is one of the most popular sporting activities in individuals with spinal cord injury.<sup>1</sup> Marathon racing over a 42 km course is the latest and most strenuous of the wheelchair athletic events. A paraplegic wheelchair marathon requires maximum endurance power for a long period of time. Previous studies have investigated the physiological and anthropometric characteristics of wheelchair marathoners.<sup>2–5</sup> For example, it has been shown that the mean oxygen uptake of elite wheelchair athletes during a marathon was fairly low ( $\sim 35.0$  mL/kg/minute) in comparison with able-bodied elite runners. However, the paraplegic athletes had a high mean heart rate ( $\sim 170$  bpm) throughout a marathon.<sup>2</sup> Power of the upper arms, lung vital capacity, isokinetic muscle strength of the elbow extensors, muscle endurance of triceps brachii, and total push angle may all contribute to wheelchair marathon performance.<sup>3–6</sup>

In the field of wheelchair racing, marathons have become popular since the beginning of the 1980s.<sup>1–7</sup> In contrast to marathons in able-bodied runners,<sup>8,9</sup> there is no available research data on the participation and performance trends in wheelchair

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marathon performance across the last three decades. Due to the increase in social interaction of people with disabilities and the improvements in material,<sup>10–13</sup> technique, and training over the past three decades,<sup>14,15</sup> an increase in the participation and improvement in wheelchair marathon performances since the 1980s for both males and females could be envisaged.

Neither gender nor age differences have been investigated in wheelchair marathons. It has been shown that over the past 30 years, the participation of able-bodied females in marathon running has grown dramatically and, during the same period, female marathon performances have improved at a remarkable rate.<sup>16</sup> The gender differences in the performances of elite marathon runners varied across the same years but has not systemically decreased or varied since the 1980s.<sup>17</sup> Also, gender differences in both elite and master able-bodied marathon running performances has stabilized nowadays to ~12%.<sup>9,17</sup> However, it is unknown if gender differences have changed in wheelchair marathon performances since females have participated. In addition, able-bodied males and females seem to physiologically peak at a similar age in marathon running performance.<sup>17</sup> However, the age of peak performance for both male and female wheelchair marathoners is not known.

This study focused on the Oita International Wheelchair Marathon in Oita, Japan, which is one of the oldest and most famous wheelchair marathons in the history of wheelchair racing.<sup>2</sup> In commemoration of the year of the disabled, the first Oita International Wheelchair Marathon – which was in fact a half-marathon distance (21 km) – was held in 1981 (<http://www.wheelchair-marathon.com>). The first full marathon (42 km) took place at the third meeting in 1983. This full marathon was officially recognized by the International Stoke Mandeville Game's Federation. Since 1983, the Oita International Wheelchair Marathon has been held each year and many elite wheelchair racers from several countries have participated in this event.

The aim of the current study was twofold: (1) to examine the changes in participation and performance at the Oita International Wheelchair Marathon for both males and females between 1983 and 2011, and (2) to analyze gender differences in the ages of peak wheelchair marathon performance.

## Methods

Approval for this study was obtained from the Burgundy University Committee on Human Research. It involved the analysis of publicly available data so informed consent was waived. Data were obtained through the Oita marathon website (<http://www.wheelchair-marathon.com>). The Oita

International Wheelchair Marathon is exclusively reserved for wheelchair athletes. The Oita International Wheelchair Marathon is a yearly event held in October. This international race gathers wheelchair athletes from all over the world to participate in full and half-marathon racing. It started in 1981 to commemorate the International Year of Disabled Persons.

In the current study, all female and male wheelchair athlete finishers were considered independently of their disability classification. The changes in the age of wheelchair athletes (ie, winner, top three overall, and overall finishers) were analyzed from 2003 to 2011, and the changes in performance (ie, winner, top three overall, and overall finishers) were analyzed from 1983 to 2011. Gender differences in marathon performance were examined for the winners and the top three overall finishers from 1983 to 2011. The gender difference in performance time was calculated as follows: (female performance time – male performance time)/male performance time × 100.

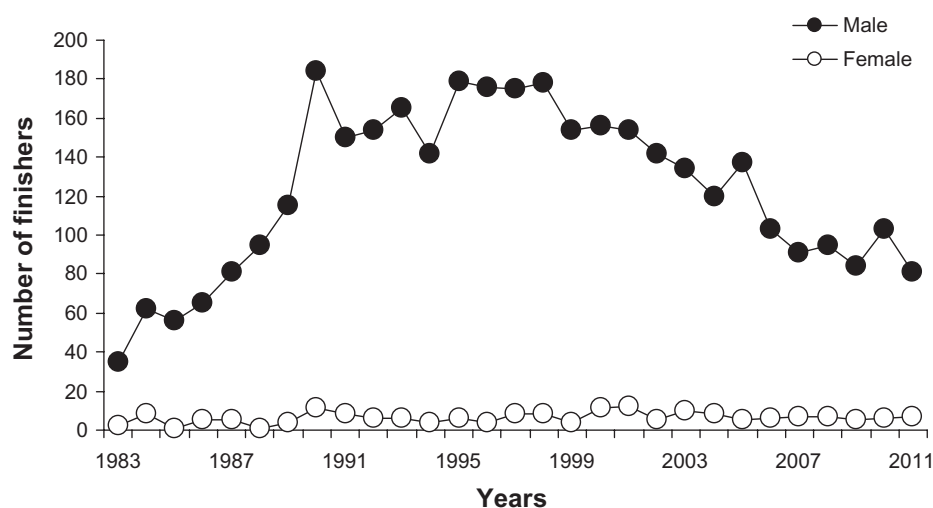
## Statistical analysis

Data is reported as mean ± standard deviation in the text. One-way analysis of variance was used to compare the age and performance times between male and female winners across the years. A two-way analysis of variance, with between factors for sex and years, was used to compare age and performance times between males and females across the years. Tukey's post hoc analyses were used to test differences within the analyses of variance when appropriate. A significance level of  $P < 0.05$  was used to identify statistical significance. Statistical analysis was performed using the STATISTICA for Windows version 6.0 (StatSoft, Inc, Tulsa, OK).

## Results

From 1983 to 2011, there were a total of 3566 male finishers and 180 female finishers in the Oita International Wheelchair Marathon. The number of finishers each year over the history of the event is shown in Figure 1. There was a progressive increase in the number of finishers from 1983 to 1990, which then stabilized for 10 years before there was a progressive decrease until 2011. The average number of finishers per year was  $123 \pm 43$  for males and  $6 \pm 3$  for females. Female finishers represented  $5.0\% \pm 2.0\%$  of all finishers over the 1983–2011 period.

Figure 2 shows the historical age trends of the male and female winners, top three overall finishers, and overall male and female finishers between 2003 and 2010. During the studied period, the mean age of the winners was not significantly different ( $P > 0.05$ ) between the males ( $35.2 \pm 9.7$  years)



**Figure 1** Number of finishers at the Oita International Wheelchair Marathon, by gender, from 1983 to 2011.

**Note:** Female finishers represented  $5.0\% \pm 2.0\%$  of all finishers over the 1983–2011 period.

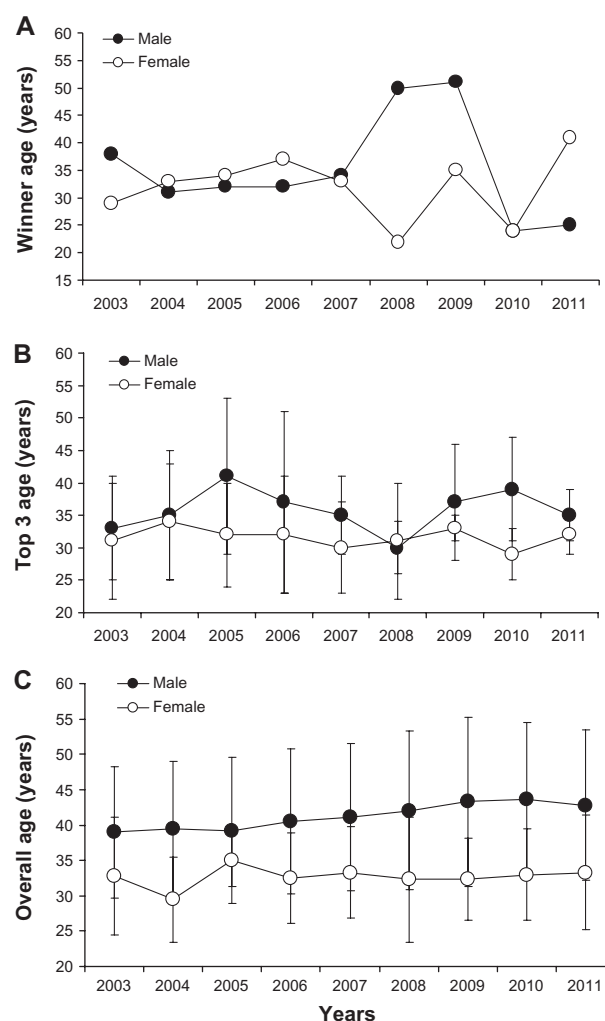
and the females ( $32.0 \pm 6.1$  years) (Figure 2A). Similarly, the mean age of the top three overall finishers was not different between males ( $35.8 \pm 3.2$  years) and females ( $31.6 \pm 1.5$  years) (Figure 2B). There was no significant sex/year interaction for the age of overall finishers. Independent of the year, the mean age of overall finishers was significantly ( $P = 0.026$ ) greater for males ( $41.3 \pm 1.8$  years) compared to females ( $32.7 \pm 1.4$  years) (Figure 2C).

The historical time performance trends of male and female winners, top three overall finishers, and overall male and female finishers between 1983 and 2011 are shown in Figure 3. The race times decreased progressively from 1983 to the late 1990s, but then tended to stabilize for winners, top three, and overall finishers. During the 1983–2011 period, the race time was significantly lower ( $P < 0.01$ ) for males compared to females for both winners and top three overall finishers (male winners  $1:32 \pm 0:11$ ; female winners  $1:52 \pm 0:17$ ; top three males  $1:34 \pm 0:11$ ; top three females  $1:59 \pm 0:20$  hours:minutes). In contrast, the race time of overall finishers was not significantly different between males ( $2:06 \pm 0:12$  hours:minutes) and females ( $2:12 \pm 0:18$  hours:minutes).

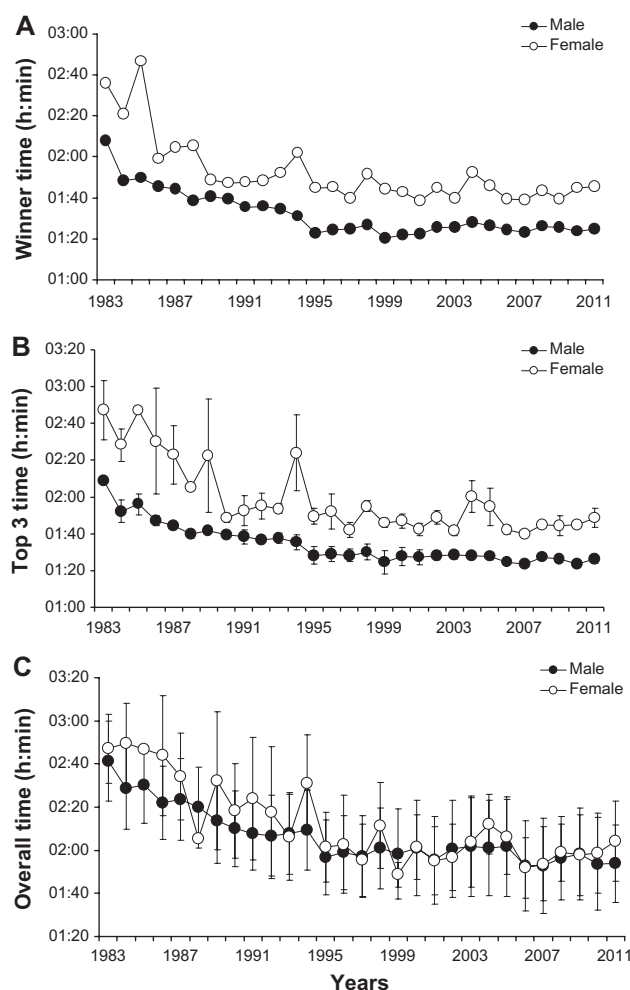
Figure 4 shows the historical trends of gender differences in performance for the winners and the top three overall finishers. Gender differences did not change across the years for both the winners and top three. The mean gender difference in race time was  $22.1\% \pm 8.7\%$  for the winners and  $26.1\% \pm 9.7\%$  for the top three overall finishers.

## Discussion

There were three main findings in the current study. First, the participation of male athletes in the Oita International



**Figure 2** (A) Mean age of the male and female winners, (B) mean ( $\pm$ standard deviation) age of the overall top three male and female finishers, and (C) mean ( $\pm$ standard deviation) age of the overall male and female finishers at the Oita International Wheelchair Marathon from 2003 to 2011.



**Figure 3** (A) Mean performance times of the male and female winners, (B) mean ( $\pm$ standard deviation) performance times of the overall top three male and female finishers, and (C) mean ( $\pm$ standard deviation) performance times of the overall male and female finishers at the Oita International Wheelchair Marathon from 1983 to 2011.

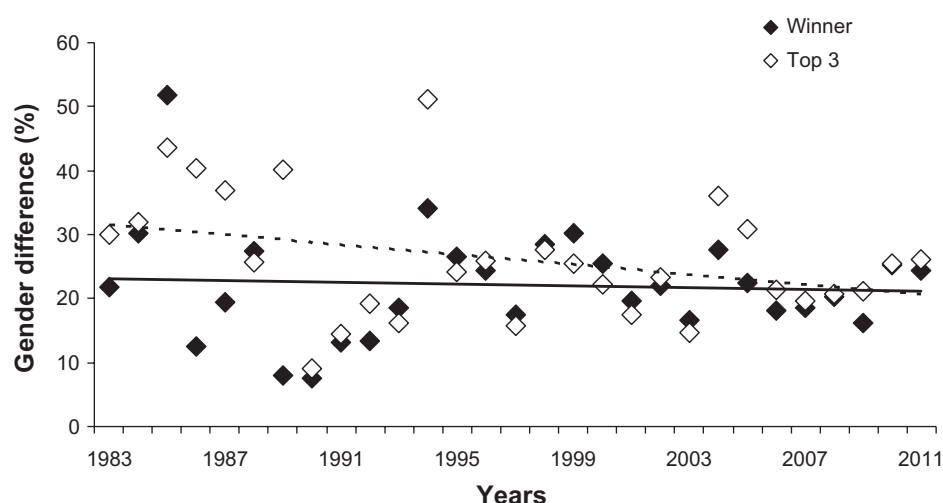
Wheelchair Marathon reached its highest level in the 1990s, but tended to decrease after the year 2000. The participation of female wheelchair marathoners remained low at ~5% of the total field. Second, wheelchair marathon performances tended to stabilize from the end of the 1990s for both elite male and female athletes. Gender differences in performance were quite stable around 22%–26%. Third, the age of peak performance was similar between male and female wheelchair marathoners, ranging 32–36 years.

Participation in the Oita International Wheelchair Marathon increased from the first event in 1983 until the late 1990s, and there were more than 180 finishers annually during the 1995–1998 period. However, from 1999, the number of finishers regularly decreased, with less than 90 finishers in 2011. In the field of able-bodied distance running during the approximately same timeframe, there has been an increase

in participation in prestigious international marathons such as the New York City Marathon and ultraendurance offroad running races such as the 161 km ultramarathons.<sup>9,18,19</sup> This increase in long-distance running participation was especially observed for master runners (ie, >40 years old) for whom enjoyment, health, fitness, social benefits, and competition are the main drivers.<sup>20</sup> Because the age of wheelchair athletes was only available from 2003 for the current study, it is not possible to draw any conclusion about the possible relative change in the mean age of wheelchair marathoners during the past decades. The assumption that wheelchair athletes have now preferentially moved to shorter distance races, such as track and field events or half-marathon road racing, needs to be explored.

During the 29-year period studied, the rate of participation of female wheelchair marathoners remained at ~5%. This rate of female participation is much lower compared to female able-bodied marathon runners. For example, female participation at the New York City Marathon nowadays represents more than 30% of the total field.<sup>8,9</sup> The very low participation of females in wheelchair marathons needs to be verified for shorter track and field or road competitions. Material, training facilities, and support are the same for male and female athletes with disabilities so the main reasons for such a low involvement of females in wheelchair racing may be linked to social reasons (eg, family, children, and household). Motivational differences between female and male wheelchair athletes might also be a potential reason, where males seem to be more motivated to compete in wheelchair sports to win.<sup>21,22</sup>

In addition to the low rate of female participation, the current results show that the mean age of finishers was lower for females (~33 years old) compared to males (~41 years old). This observation contrasts with results on able-bodied runners showing that the mean age of endurance runners was similar (~40 years old) between males and females.<sup>8,9</sup> The reasons for a decrease in competitive involvement of older female wheelchair athletes remain to be clarified. However, the age of the best wheelchair marathoners was not significantly different between males and females (32–36 years old). This age seems slightly older than the peak performance age of able-bodied athletes. Indeed, it has been shown that the age of peak marathon running performance was similar between male and female runners at ~30 years old.<sup>17</sup> The current data indicate that males and females physiologically peak at a similar age in wheelchair marathon performance. It would be interesting to further examine if wheelchair marathon running performance begins to decline from 40 years of age



**Figure 4** Gender difference in race time for the Oita International Wheelchair Marathon from 1983 to 2011.

**Notes:** Bold line represents the winner regression line ( $r^2 = 0.005$ ;  $P = 0.70$ ); dotted line represents the top three overall regression line ( $r^2 = 0.11$ ;  $P = 0.07$ ).

for male and female disabled athletes as has been observed for able-bodied endurance athletes.<sup>18,23,24</sup>

Marathon performance times of winner, top three, and overall finishers decreased during the 1980s and 1990s but have tended to stabilize over the last decade for both males and females. It has already been shown that from the first existence of an endurance event, it takes about one decade for elite able-bodied athletes to reach a more stable level of performance.<sup>25</sup> There is no doubt that improvement in wheelchair technology and training methods during the 1980s and 1990s have contributed to the decrease in wheelchair marathon times since 1983.<sup>10–15,26</sup> Racing strategies such as drafting techniques (ie, cycling directly behind a competitor) may also help to improve performance.<sup>27</sup>

During the 1983–2011 period, gender differences in wheelchair marathon performance remained quite stable at ~22% for the winners and at ~26% for the top three overall finishers. By comparison, Coutts and Schutz reported that the gender differences in wheelchair performance were 15% for 200 m and 23% for 5000 m in track races.<sup>28</sup> These data suggest that the gender differences in wheelchair performance may be greater for endurance events compared to sprint events. However, the gender differences in wheelchair marathon performance are much greater compared to traditional values (~10%–12%) reported in the literature for able-bodied marathon runners.<sup>8,9,17,29</sup> It has been shown that males have larger hearts, less body fat, greater hemoglobin concentration, more muscle mass per unit of body weight, and a larger maximal oxygen consumption that contribute to the faster marathon able-bodied running times compared to females.<sup>30,31</sup> The larger capacity of males to consume oxygen

per body weight appears to be the primary factor determining the gender difference in distance running for able-bodied athletes.<sup>30</sup> However, to date, comparison of physiological factors that limit endurance performance (eg, maximum oxygen uptake, lactate threshold, and efficiency) between male and female wheelchair marathoners are missing. Additional physiological or anthropometrical factors could explain the greater gender differences in marathon performance between athletes with and without disabilities. Lower muscle power of the upper arm and grasping force of hands in females compared to males may limit the power production during a 2-hour effort such as a marathon.

## Conclusion

This paper is the first to describe the participation and performance trends in the Oita International Wheelchair Marathon from 1983 to 2011 for both males and females. During a 29-year period, the rate of participation of disabled female athletes in wheelchair marathons has remained extremely low. After an initial decrease in the 1980s, performance times have stabilized since the late 1990s for both male and female wheelchair marathoners. Even if the mean age of overall finishers is lower for females than for males, the age to peak performance is similar for both male and female wheelchair marathoners. The gender difference in performance for wheelchair athletes (22%–26%) was greater compared to able-bodied runners (10%–12%). Future studies need to investigate the reasons for the low participation of females in wheelchair marathons and why the gender differences in marathon performance are much greater for disabled athletes than for able-bodied athletes.



## Disclosure

The authors report no conflicts of interest in this work.

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